A Plan for Testing the Theory of Complete Tooth Nutrition

By

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Introduction.

The Swedish Medical Research Council has assigned to the writer the task of drawing up a plan for testing the writer's theory that a complete tooth nutrition acts as a sure dental caries prophylaxis, Åslander (1963 d). Such a plan must be founded on experiments carried on over many years. For that reason it would be of great value if somewhat identical experiments could be started simultaneously in several places around the world so that without unnecessary delay the influence of varying living conditions could be ascertained. Accordingly this general plan is put forward.

The theory of complete tooth nutrition.

A tooth is a living tissue; not a dead mineral structure. And a tooth is an independent individual that grows out of the mandible in somewhat the same way as a plant grows out of the soil. The plant receives nutrients from the soil solution, the tooth from the blood stream. The growth of both are governed by the same laws of nutrition. One of these is that any living and growing individual needs a complete set of nutrients in order to attain a normal development. If one or more of the essential nutrients are lacking or present in too small quantities, then severe deficiency diseases will arise. Thus, for the development of a normal tooth a complete supply of tooth nu-

trients is necessary. If a tooth does not receive complete nutrition, deficiency diseases will set in. In other words, dental caries is a deficiency disease. Only starved teeth are attacked by dental caries. A complete tooth nutrition, especially during tooth formation, will produce teeth that are highly resistant to or immune against dental caries. Thus our battle against dental caries should be waged in order to promote the growth of normal teeth, just as our wild animals grow normal teeth free from dental caries. The difference between wild animals and Man with reference to dental caries is that the animals grow up in a natural habitat where the feed is sufficiently rich in tooth nutrients, whereas Man, especially in industrialized countries, is living in a highly artificial habitat and on processed foods that are very deficient in tooth nutrients. In order to grow healthy teeth Man must supplement the daily fare with tooth nutrients.

Historical.

A. *The birth of the new theory.* As a small boy the writer suffered badly from toothache. At that time, more than sixty years ago, official dental care was non-existent. Dental caries in children was regarded as something akin to mumps and measles, something quite natural for children. But for the writer this toothache was something horrible and unforgettable. When at a mature age I was to become a father — in 1938 — I was determined to try to protect my children from dental caries. According to my view of the matter, this could be achieved in two ways. The children could be brought up on a daily fare completely free from cariogenic foods, or the resistance of the teeth to dental caries could be strengthened. The first way appeared almost impossible to follow, especially as for private reasons it was necessary to base the daily fare on inexpensive foods, such as carbohydrates. The other method: to improve the quality of the teeth by better tooth nutrition, seemed to be far more interesting and promising.

The writer had at that time, in 1938, a long experience of research in plant nutrition, where the effects of a deficient mineral nutrition were often noted. Deficiency disease in farm animals caused by an insufficient supply of minerals had also been observed. For these

reasons it was quite natural to regard dental caries as a deficiency disease caused by an insufficient supply of tooth nutrients. And the most likely tooth nutrients appeard to be the minerals that form the tooth structure. I at least had good reasons to believe that my poor deciduous teeth, which gave me such painful toothache, was the result of phosphate starvation. The writer grew up on a dairy farm in northern Sweden. Some years prior to my marriage I had the opportunity to examine the soil types on the parental farm. They were found to be very poor in plant-available phosphates, Åslander (1932). And in my babyhood the phosphate deficiency must have been still more pronounced as phosphate fertilizers were then used very sparingly. Crops grown on soils poor in phosphate are likely to contain a low percentage of phosphorus. Thus the foods for the family and the feeds for the cattle on the parental farm were low in phosphorus. Moreover, in those days the daily fare at my home consisted almost entirely of home-made products. I grew up on a diet poor in phosphates — and got poor teeth. These considerations induced me to give the first-born baby small daily doses of a soluble phosphate, $CaHPO_4$, as soon as the mother's milk was supplemented by other foods. The first doses were almost microscopic, but they were slowly increased, so that at the age of two the child received a daily dose of about 2 grammes. Both the child and the teeth grew splendidly.

B. *The bone-meal period.* The phosphate treatment apparently gave excellent results — perhaps too good. The results could, in part, also be due to a very careful nutrition given to the first-born. For the more common upbringing of children a more comprehensive tooth nutrition might be necessary. Bone meal appeared to be the answer. It contains, in addition to calcium and phosphorus, as in $CaHPO_4$, a number of trace elements, some of which could be of importance as tooth nutrients. The choosing of bone meal was quite natural. Already in my babyhood bone meal was used as a mineral feed, especially for pigs. And bone-eating was an old practice. The writer's parents, born about 100 years ago, grew up with perfect teeth on a daily fare not very different from the one the writer was brought up on forty years later. But a significant difference was that the parents were bone-eaters. The small Baltic herring was roasted over the open fire and eaten — daily — with head and

tail, bones and everything. Apparently this bone-eating gave children perfect teeth. When the writer grew up, this bone-eating had been discarded for more "proper" table manners. And thus the writer got very poor teeth indeed. Bone-eating could not be resumed. But bone-meal eating could. Thus we decided to feed our children with bone meal. This change-over from phosphate to bone meal took place in the autumn of 1940.

C. *The publication of the new theory.* In 1948, when tooth nutrition had been practised for ten years with the writer's children as guinea-pigs, the results were so outstanding that it appeared imperative to publish them. At that time three children were free from dental caries in a community where otherwise all the children suffered from tooth decay, often very severely, as could be ascertained by looking into the mouths of our children's playmates. A small daily dose of bone meal given to the children had apparently made all the difference, Åslander (1948).

During the period 1940—1948 the writer's attention was brought to an experiment with bone meal in the U.S.A. In the Swedish edition of Reader's Digest, Det Bästa, there appeared in 1944 an article describing an experiment by Harootian, (1943). He gave bone meal to some of his mature patients who had had especially severe attacks of dental caries. After a period of nine months he was able to record very good results from the bone-meal treatment. However, the writer did not pay any very great attention to this experiment. In the first place the results appeared to be too good. Fully-grown teeth could hardly be so easily affected. And the results had no bearing on the writer's interest in the nutrition of *growing teeth.* Especially one sentence in the article appeared to be too dogmatic. It ran: "To use bone meal without the careful advice of a physician is very dangerous". Bone meal contains fluorine — a common constituent in rat poison! If the dramatic sentence had been accepted then I should at once have stopped my children's bone-meal diet. Fortunately, the sentence was obviously too exaggerated. My experience was that bone meal had for a long time been given to farm animals in compartively large doses with only beneficial results. The small doses, about 2 grammes a day, that I was giving my children must be harmless. I disregarded the article. — Some years later (1952) the Royal Medical Board of Sweden published the results

of a comprehensive investigation into the cariogenic effects of carbohydrates. In this investigation bone meal was given to mature persons. No significant caries-protective effect was recorded, which is in full accordance with the writer's theory of complete tooth nutrition. The caries-protective effect of bone meal is produced in *growing teeth, not in full-grown teeth.*

D. *Further investigations.* When the nutritional theory, Åslander (1948), had been published the writer had no intention of performing any more experiments outside the family. In the first place, the new theory appeared to be so well founded that it ought to have been taken up at once by experts on nutrition, so that comprehensive investigations could be started immediately. And secondly, the writer had no time for experiments on a large scale. Other research work took up more than the time available.

Unfortunately, the writer's expectations did not materialize. The theory of complete tooth nutrition met with a compact negativism. It became shockingly evident that if any further investigations were to be made the writer had to undertake them himself. A plan for testing the theory with 1,000 pregnant mothers and their ensuing children until all the teeth were formed was drawn up in the autumn of 1948 and submitted to the Board of a foundation which, according to the founders' rules, was to try to prevent human suffering. No answer has been received as yet! In the fall of 1950 The Royal Board of Health announced that a great campaign was to start against dental caries. The writer then in a letter suggested that the Board should include in the plan a test of the bone-meal method. No answer has been received and no test was ever made. In 1952 an article was printed in the American journal Prevention and it established good contacts, Åslander (1952). In 1956 a popular booklet in Swedish was published and spread within Scandinavia, Åslander (1956). Zimmermann (1956) spread the new theory to Germany. As a preliminary to a determination to write a scientific paper on the subject some odontological literature was studied in 1957. The writer was then shocked to find that not only was the acid fermentation theory suggested by Miller (1890) declared to be the cause of dental caries but the Miller theory was so insistently emphasized that the study of the textbooks came close to brainwashing. No wonder so many dental people have found it impossible to grasp the theory of com-

plete tooth nutrition! But it must be admitted that the writer has subsequently received many reprints from various parts of the world in which dental caries has been discussed far better than in the text books. As a result of studies and some laboratory work several reports have been printed, Åslander (1958, 1960, 1963 b, 1963 c). — During the period 1948—1963 the writer submitted to the Government, the Medical Research Council and a number of other boards, at least a dozen applications for funds for testing the theory of complete tooth nutrition, but to no avail. However, a good many parents both in Sweden and abroad have been willing to test the bone-meal method on their children. When the writer's instructions have been fellowed the results have been excellent. Caries-free children have been reported.

Mention must be made in this connection of the great part played by the writer's wife. She became of course very concerned when the writer proposed the mineral feeding of the new-born baby, but she had full confidence in the father's reasoning and gave day after day, week after week, month after month, year after year a *daily* dose of tooth nutrients. And when the children grew up with perfect teeth the mother became the corner stone of the new theory. She convinced many mothers of the usefulness of the bone-meal method and she made out recipes for bone-meal bread, bone-meal buns, bone-meal cookies, bone-meal candies etc., all of them very delicious and without any "bone-meal" taste. And, not least, my wife always supported the work, which mostly had to be done in the writer's spare time, so that home life was impaired, and she never complained when household money had to go to the printing and distribution of reports. It is this unselfish support that has made possible the work on the theory of complete tooth nutrition.

Tooth nutrients.

A special brand of improved Swedish bone meal that has been used by the writer for more than 20 years has produced caries-free teeth in children when taken daily from the earliest possible date until all the teeth were formed. This fact is taken as proof that this brand of bone meal contains all the nutrients that the teeth need under prevailing conditions. The main part of the bone meal

is made up of various minerals. Thus it seems safe to assume that it is the minerals in the bone meal that in the first place are to be considered essential tooth nutrients. They form the mineral structure of the teeth and some of them may also act as catalysts. In addition, bone meal contains some organic matter which is probably of some importance; at least it seems to prevent fluorine poisoning. Roholm (1939) found that bone ash in which the organic matter had been burned off caused fluorine poisoning in cattle. Normal bone meal has never had any harmful effect, so we must assume that the organic matter in bone meal acts as an antidote. It may also have other important actions. For that reason it is preferable with a somewhat high content of organic matter. The more processed the bones are the less the content of organic matter.

Up to date the following minerals have been found to be essential tooth nutrients: calcium (Ca), phosphorus (P), strontium (Sr), fluorine (F), vanadium (V) and molybdenum (Mo). All of those minerals are found in bone meal, which explains how it is that the bone meal has produced perfect teeth, free from dental caries, Åslander (1960). In addition, bone meal contains a number of other minerals, some of which may eventually be found to be essential tooth nutrients. Bone meal may be regarded as a horn of plenty as far as tooth nutrients are concerned.

The Swedish bone meal used by the writer is made of *all* the bone af *all* the animals slaughtered, including bone marrow, horns and hoofs. In this way this bone meal will be of a rich composition, which may explain the good results obtained. In order to make the bone meal still more comprehensive the manufacturer adds small amounts of iron (Fe), iodine (I) and cobalt (Co). These additions have been found to improve the feeding value of the bone meal for small pigs. (And the metabolism in small children is probably very close to the metabolism in small pigs.)

Bone meal has met with several objections, none of them to be taken seriously, with the exception that vegetarians will find it repulsive. For them a special form of tooth nutrient has been composed. Bone meal has a somewhat varying content of fluorine, a fact that has caused unnecessary discussion. Fluorine in household water has been found to be harmful. In bone meal the organic matter present seems to make the fluorine harmless. The small variations of

fluorine in bone meal are without any significance. Bone meal has also been declared an unclean product. That is an out-of-date objection, at least regarding the bone meal used by the writer. (Bone meal manufactured as an artificial fertilizer is, of course, unsuitable for human beings.) And it must be pointed out that bone meal for human consumption should be sterilized in order to make it safe and more appetizing.

The content of radioactive strontium, Sr^{90}, in bone meal has been stressed in some discussions, especially in the U.S.A. It has been pointed out that the radioactivity makes bone meal dangerous as a food supplement. However, the danger seems to be vastly exaggerated. In the first place, the content of Sr^{90} in bone meal is — according to analyses made here in Sweden — so low that it is far below the harmful level. Secondly, bone meal is taken in very small amounts compared with the large amounts of some foods, such as vegetables, fruit and milk, which are other sources of Sr^{90}. And finally, it has been shown that only small traces of the Sr that we obtain in foods are retained in the body. Around 99 per cent are excreted in the urine and faeces, Underwood (1962). Apparently, bone meal is harmless.

In view of the highly exaggerated fear of bone meal as a carrier of Sr^{90} it has been stated that it would be possible to use rock phosphate instead of bone meal, as rock phosphate is free or very nearly free from Sr^{90}. However, rock phosphate is absolutely unsuitable for another reason. Rock phosphate is very rich in fluorine. Samples that have been analysed here have shown a content of 2—4 per cent fluorine. A daily dose of two grammes of rock phosphate would contain from 40 to 80 milligrammes of fluorine. Fluorine poisoning would be an inevitable result.

For vegetarians a pure mineral composition has to be made, as far as possible identical with an improved brand of bone meal. But it must be admitted that we cannot guarantee that such a mineral composition is as effective against dental caries as improved bone meal has proved to be. The organic matter in bone meal may be of some importance. However, a mineral composition resembling bone meal ought to be tested. And it may be possible to add some organic matter which improves the effect without being objectionable to vegetarians. But it must be pointed out that all samples of calcium

phosphate, $Ca_3(PO_4)_2$, a salt very suitable for composing the main part of a mineral composition resembling bone meal, contains fluorine, often in considerable amounts. The phosphate used should be analysed; a suitable amount of fluorine is not more than 500 milligrammes per kilogramme of phosphate.

Bone meal, at least the improved brand used by the writer, has been shown to produce caries-free teeth when used according to the rules that have been worked out. However, the aim must be to compose such a mixture of tooth nutrients as will produce perfect teeth. That may take some time and a good deal of cooperation, but until this goal is reached improved bone meal should be used in order to test the theory of complete tooth nutrition.

It must also be emphasized that in an experiment in which tooth nutrition is to be tested the general nutritional conditions must be adequate if good results are to be obtained. If the main food is tea or coffee and white bread no marked effect of special tooth nutrients is to be expected. The daily fare must be more substantial. In some places the need for vitamins must be controlled. Here in Sweden such a requirement seems to be of but little importance. The daily fare is in most cases adequate — some staple foods are vitaminized — and vitamin pills or vitamin solutions are sold in great quantities, at any rate during the winter. But it must be admitted that, especially in Norway, a good effect has been obtained by way of dimishing dental decay by giving a daily dose of cod-liver oil to children. — The writer's children received vitamins on the advice of the official local infant-care institution.

Proposed plan.

The investigation is primarily a nutritional one. As experimental objects animals or children can be used.

A. *Experiments with animals.* Nutritional experiments with animals have many advantages. It is possible to use very severe conditions. If an experimental animal expires it does not mean more than a step beyond its power of resistance. And the results are gained rapidly — a very important point in a hectic world. However, when it is a question of the influence of the nutrition on the development of the teeth experiments with animals have some disadvantages.

In 1956 the writer had an opportunity to use the Syrian hamster in some experiments to show the influence of bone meal on tooth formation. Among the conditions of the grant from the Medical Research Council it was stated that the plan was to be approved by experts. To a very artificial feed mixture bone meal was added in increasing amounts. However, the result was that the addition of bone meal had very little influence on the caries frequency. This result had to be investigated. It was then found that a Syrian hamster that has reached the weight of 50 grammes so that it can be put on the experimental diet has already a complete or almost complete set of teeth. And the teeth are permanent. Thus, the nutritional experiment was caried out on *full-grown teeth!* No wonder the influence on the frequency of dental caries was slight. A bone-meal diet designed to establish a complete tooth nutrition can materially influence the caries resistance of the teeth only when applied to *growing teeth.* For that reason conventional experiments with animals of the Syrian hamster type cannot be used in determining the caries-protective properties in bone meal. And another observation was made. If a mother hamster with a litter did not receive a plentiful ration very rich in proteins the mother turned cannibal and devoured her young. That means it would be very hard to try to start the experiment with hamsters during the time the teeth are being formed, that is during suckling time. On the whole, nutritional experiments with small rodents with a view to studying the influence of the nutrition on the *development* of teeth are very difficult to arrange. The writer has no desire to venture on such a precarious path.

B. *Experiments with children.* Children are, from the nutritional point of view, ideal guinea-pigs. The experiment can begin with the pregnant mother. The child is born without teeth, and the teeth are formed very slowly, so that the daily dose of tooth nutrients can be very small, i. e., no danger of overdosing is to be feared. And a child produces both deciduous teeth and permanent teeth. It is possible to study the effect of tooth nutrition on both sets of teeth. The only drawback with nutritional experiments with children is that one has to wait several years before the result is obtained. But in these times of stress such a slow-motion experiment ought to be soothing to the nerves!

Experimental technique with children.

A. *Pregnant mothers.* According to the theory of complete tooth nutrition the administering of tooth nutrients must begin well in advance of tooth formation. For that reason it is advisable to start with the pregnant mother. At least during the second half of the pregnancy tooth nutrients should be taken. Of bone meal, 2—3 grammes a day ought to be a suitable dose. It is advisable to start with a much smaller daily dose and to increase it gradually.

B. *New-born babies.* The writer began to give his own babies bone meal as soon as the mother's milk was supplemented with other foods. A few drops of freshly squeezed orange juice was given when the babies were a few weeks old. An extremely small amount of bone meal was added to the juice. The amount was increased slowly — and later on was mixed in solid foods — so that at the age of two the daily dose was about 2 grammes. As this method gave perfect teeth it seems that it can be recommended.

C. *Older children.* According to the theory of complete tooth nutrition tooth nutrients should be given until all the teeth are fully-grown — and preferably throughout life. At the age of two and upwards a daily dose of 2 grammes has been found suitable. During periods of rapid growth a daily dose of 3 grammes may prove necessary — depending on the quality of the daily fare. The more fruit and raw vegetables in the daily fare the less the need for special tooth nutrients. On the other hand the more processed the foods, white sugar and white flour, the greater the need for tooth nutrients. The mineral content of the water supply is also important.

If for some reason it is difficult to start tooth nutrition with the pregnant mother or even with the new-born baby, it is possible to start with children at the age of 2. But it must be borne in mind that if a start is made at that age it will show but little or no influence on the deciduous teeth, only on the permanent teeth. It must also be pointed out that if the permanent teeth are to be free from dental caries it is imperative to start already at the age of about 2. To start at an age of 4 or 5 is too late. The results will then be very unsatisfactory. One must start *well in advance* of tooth formation. And tooth formation starts very early; on the permanent teeth already at the age of two.

Misconceptions concerning the nutritional theory.

In the Journal of the Dental Association of South Africa Cohen (1963) states that experiments with bone meal "consistently failed to demonstrate caries-preventive properties in bone meal". This statement seems to be based on experiments that have nothing to do with the writer's theory of complete tooth nutrition or the writer's bone-meal method. It has thus no foundation in fact.[1]

The rules governing the practical application of the theory of complete tooth nutrition, the bone-meal method, are:

1. An early start, preferably with the pregnant mother.

2. An early start with the baby, preferably during the first month of life.

3. Continuous feeding with bone meal until all the teeth have been formed.

4. A bone meal of known quality must be used.

5. A suitable daily dose of bone meal, not too small and not too large.

6. Suitable dental care. If brushing is done, a *soft* tooth brush must be used. The dental plaques must not be destroyed. According to the writer's view the dental plaque is a natural protection for the teeth. Tooth pastes should not be used. They are considered harmful. The aim of dental care should be only to remove food residues on and between the teeth. If left, such residues are apt to putrefy and to produce foul breath.

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[1] Laetherman (1963) writes: "*Bone meal as a caries preventive.* The Commission on Dental Research, in response to a request from the Dental Association of South Africa, recently conducted a survey of current research into the use of bone meal for the prevention of dental caries. After studying the replies received from the Commission members and other authorities consulted, the Commission is of the opinion that there are no major investigations in this field at the present time, and expert opinion does not favour a repetition of experiments that have consistently failed to show caries-preventive properties for humans." This notice seems to have been reprinted in dental journals all over the world, and has thus given a very wrong view of the writer's bone-meal method.

Only when these rules have been followed can we speak of the effectiveness of the bone-meal method. Abuses of the rules can only preduce poor results.

In Switzerland Berner, Held and Piquet (1959) started with children 5—7 years old in groups of 500 and for three years gave one group bone meal, one group fluorine tablets and used a third group for control. Both bone meal and fluorine tablets reduced dental decay significantly, fluorine tablets most. — The experiment started 5—7 years too late to be of any significance as far as the bone-meal method is concerned. That fluorine tablets gave better results than bone meal at the age of 5—7 is easily explained. The tablets contain water-soluble fluorine, and it is well known that fluorine shows a certain activity on the surface of the teeth and in this way to some extent diminishes dental decay. Bone meal, on the other hand, is not soluble in water. It has no apparent surface activity, it is a food. Bone meal has to be swallowed in order to act as a nutrient. It must be dissolved in the hydrochloric acid produced in the stomach and be transported by the blood stream to the *growing* teeth in order to build up a tooth which from the core to the surface will be of such a good structure that the agents of dental caries cannot attack. And if we are going to start experiments on tooth nutrition we must be able to distinguish between *surface* action and *nutritive* action. — Why this experiment started 5—7 years too late and thus on lines quite contrary to the bone-meal method ought to be explained. Even before the start it must have been obvious that the result was bound to be poor.

Cohen (1963) bases his very wrong statement especially on an experiment in Falkenberg, Sweden, by Hall, Lind and Nyström (1962). In this experiment 200 school children at the ages of 9—12 were used as guinea-pigs. The duration of the experiment was only two years with a summer holiday in between. Bone meal was given in a bone-meal bread. The daily dose of bone meal was about half of the normal one. As bone meal, a brand of unknown quality was used. The degree of dental care is not stated, but it is known that for school children in Sweden vigorous brushing with tooth paste is recommended. The result of the experiment was that no influence on dental-caries prevention could be detected. No wonder! All the rules of the true bone-meal method had been grossly violated. It is

difficult to understand that such an experiment was ever started, and it is still more difficult to understand how Cohen (1963) in this result has been able to find any foundation for his denunciation of the true bone-meal method.

These two experiments have been mentioned in order to prevent anything like them being ever tried again. What we badly need is well-planned experiments of sufficient duration, not wrongly planned short-term activities, which only cause confusion.

Control of dental caries frequency.

The result of the experiments in complete tooth nutrition must in some way be controlled. The dental status in a group of children given tooth nutrients must be compared with the dental status in a group of children that do not receive special tooth nutrients. In order to obtain reliable results two conditions may exist:

a. The groups are as identical as possible in every aspect, including social standard and food habits. Then even a limited effect of the tooth untrients would give a reliable result.

b. The effect of the tooth nutrients are expected to be so great as to produce teeth which to 100 per cent (or very near) are free from caries. In that case the result would be so overwhelming that comparison with a selected group of children who had not been given special tooth nutrients would be superfluous or almost so.

If two groups as similar as possible were to be selected, the best way would to be to start with identical twins, one of which receives tooth nutrients and the other not. The difficulty would then be to find mothers that would consent to be partial to their children. At any rate, it is the writer's experience that such mothers do not exist. If the mother believes that one kind of treatment is beneficial, then both the twins shall have the benefit of it, and should the mother not believe in the treatment then neither of her children shall be a guinea-pig.... Groups of identical twins are theoretically ideal. In practice they are very difficult to obtain.

In areas where dental caries is common among children, it may be unnecessary to start with different groups. If the experiment starts at an early period of the children's life, with the pregnant

mother, and continues with daily doses of suitable tooth nutrients until all the teeth are formed, then — to judge from long experience — the children will be entirely or almost entirely free from dental caries. Then the experimental group will stand out so conspicuously that the result of the experiment will be very reliable indeed. In Sweden, where practically 100 per cent of the children suffer from dental caries, the writer has proposed such one-group experiments. The results would then have to be compared with the general frequency of dental caries. As far as experience during more than 20 years goes, the results wold be:

a. Children in experimental group = practically 100 per cent caries-free teeth.

b. Children outside experimental group = practically 100 per cent caries-affected teeth.

I areas where dental caries is less frequent it may be necessary to carry out the experiment with groups of children being given and not being given tooth nutrients. Then the selection must be made in such a way that the groups are as similar as possible.

The actual check on the occurrence of dental caries should be kept at least once a year or, still better, at shorter intervals.

Here a little parenthesis must be inserted. Proell (1962) has tried to make a great affair of the fact that he was able to discover microscopic signs of dental caries on lost deciduous teeth from the writer's children. To the naked eye the teeth appeared to be completely free from dental caries. As the writer, Åslander (1963 a) has pointed out, such microscopic attacks of dental caries during the last few weeks of the existence of the deciduous teeth — when the roots of the teeth are reabsorbed and thus the connection between teeth and mandibles gradually broken and the teeth are cast off — such small attacks of dental caries should not be taken seriously. They are more or less attacks on *dead* teeth, not on living teeth. At any rate, they are of no practical consequence. — The aim of an experiment with complete tooth nutrition should be to ascertain whether real caries — especially in the permanent teeth — can be prevented. That is the real problem.

Environmental factors.

The frequency of dental caries is influenced by environmental factors. Already in 1938 the writer presumed that a correlation existed between phosphate deficiency in the food-producing soil on the parental farm and the writer's early dental caries. This presumption was the first idea that suggested to him the theory of complete tooth nutrition, Åslander (1948).

Later on, a good many workers have found a correlation between soil conditions and the prevalence of dental caries. Albrecht (1948) considered the content of calcium and phosphates in the soil to be important factors influencing the health of teeth. In the New England States, where the soil is leached and poor in plant nutrients as a result of a humid climate, dental caries is very prevalent, while in an area west of the Mississippi river, where owing to an arid climate the soils are non-leached and thus rich in plant nutrients, dental caries is very much less prevalent. The correlation is simple: A rich soil (especially rich in Ca and P) = good teeth, a poor, leached, soil = poor teeth.

In Australia and New Zealand, Hewat and Eastcott (1953), Cadell (1962), and Ludwig, Healy, and Malthus (1962) all found a correlation between soil types and the occurrence of dental caries. Losee (1962) summarizes the results of several workers who have come to the conclusion that there exists a correlation between soil conditions and the occurrence of dental caries. And not only the soil but also the quality of the household water influences dental caries. Lødrup (1953) explained the good dental health in Bonn, West-Germany, and the poor dental health in Oslo, Norway, as being caused by the rich mineral content in the Bonn water (although the fluorine content is very low) and the very low mineral content in the Oslo water. Irving (1963) has studied the saline waters of Essex, England, and points out that the quality of the drinking water undoubtedly has a great influence on the occurrence of dental caries in children.

Several American investigators, East (1939), Blackerby (1943), Dunning (1953) and Hadjimarkos (1956) have found an inverse ratio between caries prevalence and the amount of available sunshine. One explanation is that in regions with plenty of sunshine

the ultraviolet radiation stimulates the production of vitamin D, which directly influences the calcification of the growing bones. But the findings may also be interpreted in another way. A sunny climate is generally an arid climate where the soils are non-leached and thus rich in soluble minerals, i. e., rich in tooth nutrients which by way of food plants and drinking water find their way to the growing teeth.

The existence of environmental factors influencing the prevelance of dental caries makes it obvious that their influence must be studied in experiments on tooth nutrition. The household water should always be analysed, especially within rural districts, where mineral-rich ground water may be used, and the soil types should be examined. The plants grown in the districts should be analysed as well as the vegetables marketed in the cities. By this means it would be possible to determine whether vegetables from a certain area are more valuable than those from other areas. It may also be possible to find out whether any particular mineral is lacking in certain areas and as a remedy to add a mineral or several minerals to the tooth nutrients to be used. The writer has found that a special brand of improved bone meal to which have been added small amounts of Fe, I, and Co has produced perfect teeth in children when it has been given from earliest babyhood until all the teeth are full-grown. That must mean that this bone meal contains all the tooth nutrients needed under the conditions prevailing within Scandinavia. But in other parts of the world some other composition of the tooth nutrients may prove necessary. Thus, it is necessary to investigate the environmental factors everywhere when experiments on tooth nutrition are started.

Summary.

1. A tooth is a living and growing structure that needs a complete nutrition in order to develop normally. And a normal tooth is highly resistant to or immune against dental caries. Only starved teeth are attacked by dental caries.

2. Essential tooth nutrients are in the first place the minerals that form and catalyse the formation of the tooth structure.

3. Our modern daily fare is too poor in tooth nutrients because the food plants are grown on deficient soils and foods are processed or handled so that tooth nutrients are lost.

4. In order to obtain a complete tooth nutrition our deficient daily fare must be supplemented by a suitable mixture of tooth nutrients. The writer has found that a special brand of improved bone meal has produced the results required, i. e., caries-free children. For vegetarians a special mixture of minerals must be used.

5. Tooth nutrition must be studied on growing teeth, not on full-grown teeth. For that reason experiments with small rodents, for instance the Syrian hamster, give misleading results. By the time a hamster can be subjected to a feeding experiment its dentation is already complete or nearly so. The result of such an experiment will thus only elucidate the influence of the feed on full-grown teeth, not on growing teeth. On the other hand, children are ideal guinea-pigs. Especially if identical twins can be used.

6. The addition of tooth nutrients to the daily fare must begin well in advance of tooth development; preferably it should begin with the pregnant mother and continue throughout the period of breast-feeding. The child should be given tooth nutrients as soon as the mother's milk is supplemented by other foods, and this should continue with small daily doses until all the teeth are full-grown, and thereafter preferably throughout life. Full-grown teeth also need nutrients in order to retain caries resistance. And a daily fare sufficiently rich in healthy minerals is probably beneficial for body and soul.

7. The environmental factors influencing dental caries should be studied, including the daily fare given to the children.

8. The result of the experiments with complete tooth nutrition, that is, the effect on the teeth, should be controlled at least once a year, preferably at shorter intervals.

9. It must be the aim of future investigations to work out suitable mixtures of tooth nutrients for varying environmental conditions prevailing around the world.

10. Finally, it must be pointed out that this plan does not claim to solve the problem of dental caries. It is only intended to be a

very modest start for investigations into the vast problem of tooth nutrition. But a start is always necessary, if only a modest one, if results are to be obtained. Our present knowledge of tooth nutrition is very scanty. We need extensive and profound investigations. We need the interest and skill of our foremost scientists in the field of nutrition. Dental caries is a world-wide malady; we need world-wide investigations. Dental caries *can* be prevented by a complete tooth nutrition, but *what* is included in the term complete tooth nutrition? And *how* to find a practical solution to the problem of complete tooth nutrition?

REFERENCE.

Albrecht, Wm. A. 1948. Our teeth and our soils. Circular 333. Agr. Exp. Sta. University of Missouri, 15 pp.

Åslander, A. 1932. Nyare undersökningar över sambandet mellan markreaktion, jordens näringsinnehåll och skördeutbytet. Summary: Studies on the correlation between soil reaction, soil fertility and crop production. Medd. Kungl. Lantbr.-akad. Vetenskapsavdelning, No. 2, 60 pp.

— 1948. Tandröta — en bristsjukdom. (Swedish only.) Dental caries — a deficiency disease. Social-Medicinsk Tidskr. No. 5. 1—2.

— 1952. A method of preventing dental caries. Prevention, Nov. 11—20.

— 1956. Benmjölsmetoden mot tandröta. (Swedish only.) The bone-meal method against dental caries. Gävle. 48 pp.

— 1958. Tooth formation in the light of plant nutrition. Report Div. Agr., Royal Inst. Technol., Stockholm 70, Sweden, No. 1, 20 pp.

— 1960. Dental caries, the bone-meal method and the cariogenic properties of sugar. Report Div. Agr., Royal Inst. Technol. No. 2, Stockholm 70, Sweden, 60 pp.

— 1963 a. Knochenmehl als Aufbaustoff für Zähne. Zahnärztl. Welt — Zahnärztl. Reform — ZWR, Nr 6.

— 1963 b. The theory of complete tooth nutrition. Lecture delivered at the 51st Annual Session of the FDI, Stockholm 1963. Report Div. Agr., Royal Inst. Technol., Stockholm 70, Sweden, No. 4, 16 pp.

— 1963 c. Symposium on dental caries and its prevention. Report Div. Agr., Royal Inst. Technol., Stockholm 70, Sweden, No. 5, 16 pp.

— 1963 d. En plan för prövande av tändernas fullnäring som kariesprofylax. (Swedish only.) A plan for testing complete tooth nutrition as a caries prophylaxis. Manuscript, distributed in 500 copies within Scandinavia, 15 pp.

Berner, L., Fernes, E., Held, A.-J., et Piquet, R. 1959. Profylaxie de la carie dentaire par les comprimés fluorés. Schweiz. Monatschr. Zahnhk. *69:* 798.

Blackerby, P. E. 1943. Intrastate geographic variations in dental caries rates. Journ. Am. Dent. Ass. *30:* 1241.

Cadell, P. B. 1962. Prevalence of dental caries in relation to New Zealand soils. Trans. Comm. IV and V, Int. Soil Sci. Conf. New Zealand. (Reprint 7 pp.)
Cohen, B. 1963. Bone meal in relation to caries. Journ. Dent. Ass., South Africa, *18:* 450.
Dunning, J. M. 1953. The influence of latitude and distance from the sea coast on dental disease. Journ. Dent. Res. *32:* 811.
East, B. R. 1939. Mean annual hours of sunshine and the incidence of dental caries. Am. Journ. Publ. Health *29:* 277.
Hajimarkos, D. M. 1956. Geographic variations of dental caries in Oregon. Journ. Ped. *48:* 195—201.
— 1960. An epidemiological study on dental caries among high-school students in Athens, Greece. Journ. Dent. Res. *39:* 590—597.
Hall, B., Lind, V., och Nyström, S. 1962. Benmjöl i skolbespisningens matbröd. Ett praktiskt kariesförsök. Summary: A clinical caries experiment with bone-meal enriched bread. Svensk Tandläkar-Tidskr. *55:* 21—27.
Harootian, S. G. 1943. The influence of administration of bone-meal fluor on dental caries. Journ. Am. Dent. Ass. *30:* 1396.
Hewat, R. E. T., and Eastcott, D. F. 1953. Dental caries in New Zealand. Med. Res. Council, New Zealand, 134 p.
Irving, F. A. 1963. Health, teeth and the natural saline waters of Essex, Symp. Dental Caries Prevention. Report Div. Agr., Royal Inst. Technol., Stockholm 70, Sweden, No. 5, 5—7.
Leatherman, G. H. 1963. Bone meal as a caries preventive. News Letter of the FDI, No. 43, July 1963, 2.
Lødrup, H. 1953. Den lave tandråtefrekvens i Bonn am Rhein, og de sluttninger man kan trekke av denne. Summary: The low rate of dental decay in Bonn-am-Rhein and the conclusions that can be drawn from it. Norsk Tannlægefor. Tid. *63:* 35—50.
Losee, F. L. 1962. Soils and human health, with particular reference to dental health. Trans. Comm. IV and V, Int. Soil Sci. Conf. New Zealand. (Reprint 8 pp.)
Miller, W. D. 1890. Micro-organisms of the human mouth.
Proell, F. 1962. Vermag Knochenmehl die Mineralisation und den Aufbau der Zähne von Mensch und Tier günstig zu beeinflüssen? Zahnärztl. Welt — Zahnärztl. Ref. — ZWR. *63:* (Reprint 9 pp.)
Roholm, K. 1939. Fluorforgiftning ved Anvendelse of Knogleaske ("Bennel") som Mineraltilskud. (Danish only.) Fluorine poisoning by the use of bone-meal ash as a mineral supplement. Ugeskrift for Laeger, *101:* 535—540.
Royal Medical Board, 1952. Tandkaries och kolhydrater. (Swedish only.) Dental caries and carbohydrates. Svensk Tandläkare-Tidskrift, Vol. 45, Suppl. 422 pp.
Underwood, E. J. 1962. Trace elements in human and animal nutrition. 2nd. Ed. Academic Press, New York and London, 429 pp.
Zimmerman, R. 1956. Ein schwedischer Beitrag zur Kariesverhütung. Zahnärztl. Mitteil. 453—455.

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